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The Government has the objective of increasing the renewable energy target from 9,500 gigawatt-hours (GWh) in 2010 to 45,000 GWh in 2020. This is an important and commendable measure to increase the uptake of renewable energy in Australia and reduce Australia's carbon emissions.

Itt is important that the measure address two other objectives also:

1. Support technologies that will blossom at a later time than 2017-2020
2. Support Australian manufacturing of renewable energy equipment.

The measure as planned will strongly support the uptake of wind energy technology and solar water heaters. This is commendable. However, the very special place of solar energy in long term solutions to climate change should be acknowledged and supported. This can be done by setting aside tranches for solar energy (photovoltaics and solar thermal electricity).

Solar energy

Solar energy is special. It is vast, ubiquitous and indefinitely sustainable. The solar resource utilised by photovoltaics and solar heat is hundreds of times larger than all other energy resources combined, including fossil, nuclear fission, geothermal and all other renewables:

- It is indefinitely sustainable;
- It utilises only very common materials;
- It uses a resource that is far larger than required to provide all of the world's energy;
- It has minimal security and military risks;
- It is available nearly everywhere in vast quantities; and
- It has minimal environmental impact over unlimited time scales.

No other energy source can make claims that come anywhere near these. Solar energy is a complete long term sustainable solution. Australia receives 30,000 times more solar energy each year than all fossil fuel use combined. More information is appended.

Special tranche for solar energy

A special tranche of 15,000 GWh should be set aside for solar energy

As outlined below, solar energy will eventually dominate clean energy markets – its immense advantages are clear. However, another decade will be required to get the cost of solar energy down to the 12c/kWh mark where it will successfully compete at large scale with wind. This means that solar energy may largely miss out on the renewable energy target stimulus, to the detriment of both Australian manufacturing and the longer term goal of using solar energy to eliminate fossil fuels.

The diversion of credits to roof mounted PV with a value set at 5 times nominal value should be ended, since it dilutes the 45,000GWh target. Special support for roof top PV should be by way of a national gross feed in tariff.

Support for manufacturing of solar technology

The rules for the 20% target should specifically encourage local manufacturing.

The Australian renewable energy R&D and manufacturing industry has been acknowledged by Government to be in a poor state after a decade of neglect. The new Australian Solar Institute, Renewables Australia and other support measures are very welcome, but will prove inadequate to meet the need to both rebuild research in Universities & CSIRO, and to assist companies through the tech transfer, development and commercialisation phase.

There is little encouragement for local manufacturing of renewable energy products. In contrast, our foreign competitors receive substantial assistance.

There are novel technologies emerging from ANU, UNSW and other research institutes. There are fledgling companies with interesting products that need tech transfer development, commercialisation and manufacturing support. Demonstration support (such as the solar flagships announced in the recent budget), while welcome, is not the most important assistance needed.

SOLAR ENERGY

Summary

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Australia receives 30,000 times more solar energy each year than all fossil fuel use combined. Australia has a significant presence in the worldwide solar energy industry, which can be built upon to create a major export-oriented technology-rich industry.

Energy supply options

There are five potentially available energy sources. These are energy from the sun (in its various forms), nuclear energy (fission and fusion), fossil energy (coal, oil and gas), tidal energy and geothermal energy.

Solar energy is available on a massive scale, and is inexhaustible. Solar energy includes both direct radiation (photovoltaics and solar heat) and indirect forms such as biomass, wind, hydro, ocean thermal and waves. The direct solar energy resource is far larger than the indirect solar energy resource. Collection and conversion entails few environmental problems. Mass deployment entails minimal security risks, because of the intrinsic safety and wide distribution of the collectors, and because of the ubiquity of solar energy – we will never go to war over access to solar energy, and solar energy technology has minimal utility to regular armies and terrorists alike.

Nuclear energy from fission has substantial problems relating to nuclear weapons proliferation, nuclear terrorism, uranium and thorium deposit limitations, and waste disposal. Nuclear fusion is still several decades away from commercial utilisation, but may make a major contribution to sustainable energy supply in the future.

Fossil fuels are the principal cause of the enhanced greenhouse effect and are subject to resource depletion. Other problems include oil spills, oil-related warfare (for example, the Gulf wars) and pollution from acid rain, particulates and photochemical smog.

Tidal energy can be collected using what amounts to a coastal hydroelectric system. Geothermal energy in volcanic regions or from hot dry rocks can be used to generate steam for district heating or to drive a steam turbine to produce electricity. Tidal and geothermal energy utilise relatively small and geographically restricted energy resources.

Photovoltaics

Photovoltaics (PV) is an elegant technology for the direct production of electricity from sunlight. Most of the world PV market is serviced by crystalline silicon solar cells. Sunlight causes electrons to become detached from their host silicon atoms. Near the upper surface is a “one way membrane” called a pn-junction. When an electron crosses this junction it cannot easily return, causing a negative voltage to appear on the sunward surface (and a positive voltage on the rear surface). The sunward and rear surfaces can be connected together via an external circuit containing a battery or a load in order to extract current, voltage and power from the solar cell.

PV has widespread use in niche markets such as consumer electronics, remote area power supplies and satellites. Now, as costs decline, millions of PV systems have been installed on house roofs in cities. The worldwide PV industry is doubling every 20 months. Production is currently 8 gigawatts per year. Mass production is causing rapid reductions in cost. A solar revolution is brewing.

Most PV systems are mounted on fixed support structures. Some PV systems are mounted on sun-tracking systems to maximise output. Others use sun-tracking concentrators to concentrator light by 10-1000 times onto a small number of highly efficient solar cells.

PV systems mounted on house roofs can be used to achieve household carbon neutrality. A collector area of about $25m^2$ is needed to carbon-neutralise a 5 star (energy rating) house with gas space heating, solar/gas water heating and efficient electrical appliances. Such a house exports more electricity to the grid during the day than it imports at night. An additional $10m^2$ of PV panel is required to offset the annual greenhouse gas emissions of an efficient car.

Hybrid PV/thermal micro concentrator systems on building roofs are being developed to provide solar PV electricity, solar water heating, solar air heating, and solar air conditioning – a complete building energy solution.

PV panels on building roofs compete with retail electricity prices, which are three times higher than wholesale electricity prices. When the cost of rooftop PV generation falls below the daytime retail electricity price (“grid parity”) then the PV industry will enjoy explosive growth as hundreds of millions of home owners adopt the technology. Grid parity is expected to be achieved in many countries within a few years, due to falling PV costs, rising fossil fuel costs, the introduction of carbon pricing and the introduction of time-of-use tariffs. Time-of-use tariffs properly reward PV systems for generating during sunny summer afternoons when peak loads caused by air conditioning, commerce and industry lead to high energy prices.

The efficiency of PV is eventually likely to rise above 60%, compared with the current world record efficiency of 42%. The cost of PV systems can be confidently expected to continue to decline for decades – as has happened with the related integrated circuit industry.

Solar thermal

Good building design, which allows the use of natural solar heat and light, together with good insulation, minimises the requirement for space heating. Solar water heaters are directly competitive with electricity or gas in most parts of the world. Solar air heaters will allow a large reduction in the heating load in many parts of the world, while solar driven air conditioning is a rapidly developing industry.

Solar thermal electricity technologies use sun-tracking mirrors to concentrate sunlight onto a receiver. The resulting heat is ultimately used to generate steam, which passes through a turbine to produce electricity. Concentrator methods are equally applicable to concentrating PV systems. The usual ways of concentrating sunlight are point focus concentrators (dishes), line focus concentrators (troughs, both reflective and refractive) and central receivers (heliostats and power towers).

There is a large crossover between the technology of solar thermal and PV solar concentrators. The concentrating systems are quite similar, with the major technical difference being the solar receiver mounted at the focus: a black solar absorber in one case, and a PV array in the other. Since current efficiencies are similar, then the cost of energy produced by the two types of system is also similar.

An important future application of concentrated sunlight is the generation of thermochemicals and in the storage of heat at high temperature to allow for 24 hour power production. Concentrated solar energy can achieve the same temperatures as fossil and nuclear fuels, either directly (using mirrors) or through the use of chemicals (thermochemicals or bio fuels) created using concentrated solar energy. In the past, heavy industry (e.g. the steel industry) was often located near coalfields, in regions that are relatively poorly endowed with solar energy. Future steel mill could be built in the iron ore and solar energy rich Pilbara region of Western Australia.

Energy efficiency

Hand in hand with the utilisation of solar energy goes energy efficiency and conservation. 'Solar energy' and 'energy efficiency' are often the same thing. For example, an energy-efficient building is a building that utilises natural solar light and heat sensibly. Walking rather than driving a car uses a small amount of solar energy (food) rather than a larger amount of oil energy. A clothesline, solar salt production and putting on extra clothing displaces an electric clothes dryer, fossil-fuel fired kiln drying of salt and electric heating respectively.

Baseload power and storage

It is sometimes claimed, wrongly, that the fact that the absence of sunshine at night means that solar energy cannot dominate energy production.

Options for the provision of stable and continuous solar power include actively shifting loads from night to daytime; wide geographical dispersion of solar systems to minimise the effect of cloud; precisely predicting solar energy output using satellite imagery; diversification of energy supply to include all renewables; and energy storage. A future large-scale day-night storage option is the batteries of million of electric cars, which will be able to provide 24 hour storage of Australia's entire electricity production.

Pumped hydro (whereby water is pumped uphill during the day and released through turbines at night to provide energy) is an efficient, economical and commercially available storage option. Lakes covering only 50 km^2 (about 2 m^2 per citizen) utilising either fresh water or seawater, would be sufficient to provide 24 hour storage of Australia's entire electricity production. In the longer term, intercontinental high voltage DC transmission will further reduce the need for storage.

Environmental impacts

The solar energy industry has minimal environmental impact. About 0.1% of the world's land area would be required to supply all of the world's electricity requirements from solar energy. Indeed, the area of roof is sufficient to provide all of Australia's electricity, using PV panels.

We can never run out of the raw materials for solar energy systems because the principal elements required (silicon, oxygen, hydrogen, carbon, sodium, potassium, calcium, aluminium and iron) are among the most abundant on earth. Old solar energy systems can be recycled without significant generation of toxic by-products. Gram for gram, advanced silicon solar cells produce the same amount of electricity over their lifetime as nuclear fuel rods. Per tonne of mined material, solar energy systems have 100-fold better lifetime energy yield than either nuclear or fossil energy systems.

The time required to generate enough electricity to displace the CO_2 equivalent to that invested in construction of a solar energy system is in the range 1-3 years, compared with typical system lifetimes of 30 years. CO_2 payback and price are directly linked (via material consumption), and so CO_2 payback times will continue to fall, and will eventually decline to below 1 year.

The future of solar energy

Renewable energy technologies can eliminate fossil fuels within 20 years.

Roof-mounted solar energy systems can provide photovoltaic electricity, hot water for domestic and industrial use, and thermal energy to heat and cool buildings. Grid parity for photovoltaics at a retail level is likely to be achieved in many countries within a few years – in other words, PV electricity from a building roof will cost less than the retail electricity price. This will lead to rapid growth in sales in the residential and commercial sectors without the need for subsidies.

Highly efficient solar cells manufactured from highly engineered materials, and placed at the focus of solar concentrators, can provide much of the world's electricity. High concentration solar thermal can provide electricity, process heat and thermochemicals.

Solar electricity, coupled with a shift to electrically powered cars and public transport, can provide most of the world's transport energy. A vast fleet of electric cars, each with large batteries, represents a massive electricity storage facility to smooth supply and demand.

Geographical dispersion of solar energy collectors, contributions from many different renewable energy technologies, storage via pumped hydro and other means, and high voltage DC intercontinental transmission, will allow a fully sustainable, zero-carbon future within a few decades.

Direct competitiveness with fossil fuels for wholesale energy supply requires the implementation of full carbon pricing and the removal or equalisation of hidden support for fossil fuels. However, this is the case for all low emission technologies, including carbon capture & storage and nuclear energy.

The average growth rate in the solar industry since 2000 is about 40% per year. If this rate of growth continued, then all of the world's electricity would come from solar energy by 2027. Whilst many technical adaptations to energy systems would be required to achieve this, there are no insuperable obstacles. There are no significant environmental or material supply constraints. A switch to a zero carbon energy supply will cost considerably less than severe climate change.

Over many decades, the cost of PV modules has been declining by about 18% for each doubling of cumulative sales. This progress is likely to continue. Calculations can be made of the likely future cost of solar energy under various assumptions. Assuming strong future growth and continually declining cost, in line with trends in past decades, solar electricity will be fully cost competitive with any other available large-scale low emission baseload generation technology within 12 years. As mentioned above, vast interim higher-cost markets (such as the residential market) will soon be available, allowing for massive growth in scale and reductions in cost in the intervening years.

In addition to direct solar energy collection, indirect forms of solar energy such as wind, biomass, wave and hydro can make important contributions. However, the indirect solar resource base is tiny in comparison with the direct sunshine utilised by PV and solar thermal. Mass deployment of some of these technologies (notably hydro and biomass) has substantial deleterious impacts. For example, PV and solar thermal enjoy a 20 to 100-fold advantage in annual energy harvest per km^2, which minimises alienation of land. In addition, PV and solar thermal avoid the need for water, pesticides and fertilisers, and do not compete with food production.

Solar energy in Australia

The solar power industry in Australia is constrained by lack of carbon pricing, lack of a time-of-use tariff, and a wide range of built-in (and often hidden) support measures for fossil fuels which keeps fossil fuel prices low. Time-of-use tariffs (whereby electricity generation and consumption has a value that varies throughout the day) are important for solar energy, since solar energy production often coincides with high daytime electricity prices driven by demands from industry and air conditioners.

Photovoltaics is an area of real Australian research and commercialisation strength. Photovoltaics is a strong innovation performer, in terms of performance metrics such as research papers, competitive grants and commercialisations. The solar research groups at the Australian National University, the University of NSW and CSIRO are the core participants in the new $100 million Australian Solar Institute.

The Government has announced a substantial target for the amount of renewable energy to be incorporated into the grid by 2020. Carbon pricing is to be introduced from 2011. Most states have a feed-in tariff for renewable electricity. These measures have the potential to drive substantial investment in renewable energy. However, the scale of the climate change problem is so large and immediate that further measures will be required to drive very rapid transformation of Australia's energy system to a low carbon future.

It is important for Australia to have a balanced energy portfolio. Greatly increased support is needed for solar energy R&D, commercialisation, manufacturing and market incentives. Solar energy is likely to be a $100 billion per year industry by 2012. Australian Government policy will need to be very supportive if Australia is to be a significant player in this vast new industry.

Support for solar energy in Australia should be focused on intellectual property (IP) generation and the export of IP-rich high-value products and services. This strategy would comprise substantial support for R&D, and professional education, coupled with strong incentives for companies to manufacture high value products in Australia for export.